National Institute of Longevity Elderly Sciences
NILES Journal for Geriatric and Gerontology
Shafeek AMA, **Internal Mammary**
Volume 6 , Issue 2
Original article

Effect of Left Internal Mammary Harvesting with Open Versus Closed Pleura on Early Postoperative Morbidity and Mortality

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ABSTRACT

Background: the left internal mammary artery (lima) is commonly utilized as a conduit in coronary artery bypass grafting (CABG). The optimal approach for LIMA harvesting remains debated**.** In this study, we aimed to assess and compare the early morbidity and mortality in patients undergoing LIMA harvesting for CABG with or without pleurotomy.

Methods: A prospective cohort investigation was conducted on 96 patients with ischemic heart disease who underwent elective CABG surgery at a single unit of the cardiothoracic surgery Department, Zagazig University, from January 2018 to December 2022. Patients were split evenly (n=48) between the CP and OP groups. Demographic characteristics, post-operative ventilation time, hospital and ICU stays, post-operative complications, and pulmonary function test results were evaluated and analyzed across two groups.

Results: The CP group had significantly shorter ventilation time, ICU, and hospital stays than OP group (5.1±0.68 vs. 7.6±1.64 hours, 2.1±0.28 vs. 3.3±0.66 days, 5.1±0.27 vs. 8.5±0.74 days; p=0.0001 respectively). CP group also had a lower post-operative complication, including pleural effusion and lung atelectasis. Pulmonary function test results showed a significant difference in post-operative forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) among two groups, with better outcomes observed among CP group.

Conclusion: This study implies that closed pleura LIMA harvesting may have superior early post-operative outcomes than open pleura harvesting. The CP group experienced shorter ventilation time, ICU, and hospital stays, as well as a lower post-operative complication. These findings support the consideration of closed pleura LIMA harvesting as a preferred technique for CABG surgery.

Keywords: Coronary artery bypass grafting; LIMA harvesting; Closed pleura; Open pleura; pulmonary function test.

Receive Date: 19/06/2023	Accept Date: 19/07/2023	Publish Date: 1/1/2024

INTRODUCTION

Coronary artery bypass grafting (CABG) is a widely performed surgical procedure to treat ischemic heart disease (IHD). The choice of conduit is a crucial factor in determining long-term outcomes after CABG[1]. Arterial grafts, known

Print ISSN 2636-3224
Online ISSN 2636-3232

for their superior patency and durability, have become the preferred option, steadily increasing over the past 20 years [2]. Among arterial grafts, the left internal mammary artery (LIMA) is highly utilized owing to atherosclerosis resistance and its excellent patency rate [3].

The use of arterial grafts in CABG has demonstrated prolonged cardiac ischemia-free periods and improved long-term survival [4]. LIMA is the most commonly employed arterial graft worldwide, and various surgical procedures exist for harvesting the vessel from its bed **[5].** Minimally invasive LIMA harvesting methods have been found to be safe and yield comparable outcomes during the learning curve [2, 5]. However, intrapleural LIMA harvesting, involving pleural cavity opening and subsequent intercostal drainage tube implantation, increases postoperative discomfort and pulmonary complications, such as atelectasis and pleural effusions [6]. This approach is technically more challenging due to the close anatomical relationship between the pleura and internal mammary artery. Conversely, extrapleural LIMA harvesting with intact pleura has shown decreased post-operative discomfort and pulmonary complications [2].

The study aimed to compare early post-operative outcomes of two LIMA harvesting approaches: pleura intact—extrapleural harvest versus pleura opening—intrapleural harvest, in patients undergoing CABG with LIMA arterial conduit. By assessing these two techniques, we aim to gain insights into their respective effects and identify the approach associated with better post-operative results.

PATIENT AND METHOD

Study Design & Participants

This prospective cohort investigation was carried out at Zagazig University Hospital's cardiothoracic surgery department between January 2018 and December 2022. The study included 96 IHD patients underwent elective CABG.

Inclusion Criteria:

The study included IHD Patients who underwent CABG and had a body mass index (BMI) of less than 25.

Exclusion Criteria:

Patients were excluded if they had concurrent heart diseases (valvular, congenital, and aortic surgery), associated pulmonary disease, chronic liver, and kidney

Print ISSN 2636-3224
Online ISSN 2636-3232

disease, decreased left ventricular function (ejection fraction, 30%), redo or emergency or high-risk CABG cases, chronic pulmonary disease (e.g., COPD), chest skeletal abnormalities developing pulmonary restrictions, or were indicated for concurrent cardiac or non-cardiac procedures and any renal or liver disease. These criteria were established based on known risk factors and potential confounders that could impact the study outcomes.

Surgical Technique:

LIMA harvesting with closed pleura is a technically challenging procedure and requires specialized expertise. We conducted a prospective trial comparing closed pleura LIMA harvesting with open pleurotomy among 96 CABG patients to evaluate its safety and efficacy. The patients were divided into two groups: the CP group consisting of 48 patients who underwent closed pleura LIMA harvesting, and the OP group (control group), consisting of 48 patients who underwent open pleurotomy.

Two surgical teams were involved in the study, with one team performing closed pleura LIMA harvesting and the other team performing open pleurotomy.

Before the surgery, all strategies were planned, and each patient included underwent a comprehensive evaluation, which involved pulmonary function tests (PFTs) in addition to other assessments. General anesthesia was administered to all patients during the surgical procedure. During the surgery, the pericardium was opened, followed by the entire mediastinal pleura, which was subsequently opened along with the LIMA among OP group. In CP group, the LIMA was dissected within the closed pleural space. Following heparinization and the start of cardiopulmonary bypass (CPB), cold cardioplegia was administered, distal anastomosis was performed, the aorta was decamped, proximal anastomosis was completed, and CPB was weaned. Hemostasis was achieved, and chest and mediastinal tubes were inserted before wound closure using standard maneuvers. Finally, patients were relocated to ICU for further monitoring and care.

Patients were assessed for chest tube drainage in ICU on second post-operative day. Chest tubes were removed without drainage, and patients were relocated to ward. Nonetheless, patients with drainage surpassing 50cc in the final six hours pre-ICU discharge or a total volume exceeding 300cc were moved to the ward with chest tubes. These tubes were extracted in ward once drainage fell below 200cc/24 hours. This protocol ensured effective monitoring and management of

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Online ISSN 2636-3232

chest tube drainage and facilitated timely removal of chest tubes, which is an important aspect of post-operative care in CABG patients.

Definitions and Measurements of Outcomes

The primary outcomes of the study were post-operative ventilation time (hours), hospital and ICU stays (days), PFTs, post-operative hemorrhage, and pleural effusion.

Post-operative ventilation time was defined as the duration of mechanical ventilation support following surgery. Hospital and ICU stays were measured in days. PFTs were conducted to evaluate lung function, including forced vital capacity percentage to be normal (FVC%), forced expiratory volume at first second percentage to normal (FEV1%), and FEV1/FVC ratio. Post-operative bleeding was characterized as a hemorrhage occurring when surgical field blood loss exceeded 600 mL/hour during the initial hour or 150 mL/hour for a subsequent 2-hour period following surgical procedure [7].

The condition is referred to as lung atelectasis when the tiny airways and alveoli collapse, and lung densities are visible on an X-ray or CT scan. Small to intermediate-sized, non-progressive, and unrelated to respiratory symptoms, pleural effusions appear within 1 to 2 days of surgery [8].

On discharge day, five days after surgery, we evaluated each of the 96 patients. Clinical information, plain chest X-rays, chest computed tomography (CT; evaluation was done by a chest doctor and surgeons and was independent of surgical technique), PFTs, and other information about the patients were collected. Using a portable spirometer, the same respiratory physiotherapist assessed FVC and FEV1 at patients' bedside across day preceding surgical intervention and once more on post-operative discharge day. All patients received daily physical therapy until discharge, along with same analgesic protocol given for first five post-operative days.

Ethical Consideration:

Before enrollment in the study, all participants or their family members received written informed consent after being fully informed of the methods to be employed and receiving approval from institutional ethical committee.

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Statistical Analysis:

Data were collected and analyzed utilizing SPSS V.26.0 for Windows (SPSS Inc., Chicago, IL) to compare outcomes between CP and OP groups. Continuous variables were represented as mean ± standard deviation, and categorical variables were represented as frequencies and percentages. Independent t-tests and chi-square tests was utilized for group comparisons. A p-value below 0.05 was statistically significant.

RESULT

Table 1 provides demographic characteristics for the 96 patients. Of these, 48 patients underwent closed pleura LIMA harvesting (CP group), while the other 48 patients underwent open pleura LIMA harvesting (OP group). The mean age of CP and OP patients was 61.1±4.7 and 60.2±5.04 years, respectively, with non-statistically significant difference across two groups (p=0.34). In terms of gender, majority of patients across both groups were male, with 35 (72.9%) and 32 (66.7%) patients in CP and OP groups, respectively (p=0.51).

Table1. Demographic characteristics of studied patients.

Variables	Studied groups		p-value
	Closed n.48	open n.48	
Age per years Mean ±SD Range	61.1±4.7 50-69	60.2±5.04 45-69	0.34
sex males females	35(72.9%) 13(27.1%)	32 (66.7%) 16(33.3%)	0.51
DM	30(62.5)	28(58.3)	0.67
HTN	31(64.6)	29(60.4)	0.68
Smoking	28(58.3)	27(56.3)	0.84
hyperlipdemia	20(41.7)	26(54.2)	0.22

The comorbidities prevalence was similar among both groups. The prevalence of diabetes mellitus (DM) was 62.5% among CP group and 58.3% among OP group (p=0.67). Similarly, the prevalence of hypertension (HTN) was 64.6% among CP group and 60.4% among OP group (p=0.68). Regarding smoking status, no statistically significant difference was observed between the two groups (p=0.84). The hyperlipidemia prevalence was 41.7% among CP group and 54.2% among OP group (p=0.22).

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Table 2 presents outcomes of post-operative assessment among CP and OP groups. The CP group exhibited a significantly shorter mechanical ventilation duration than OP group, with a mean ventilation time of 5.1±0.68 hours among CP group Vs. 7.6±1.64 hours among OP group (p=0.0001). Similarly, CP group had a significantly shorter ICU stay than OP group, with a mean ICU stay of 2.1±0.28 days in the CP group vs. 3.3±0.66 days in OP group (p=0.0001). The CP group also had a significantly shorter hospital stay than OP group, with hospital stay mean 5.1±0.27 days among CP group vs. 8.5±0.74 days among OP group (p=0.0001).

Table 2. Intensive care unit evaluation in studied groups

	closed	**open**	P
Ventilation time(hour)	5.1±0.68	7.6±1.64	0.0001
ICU stay(day)	2.1±0.28	3.3±0.66	0.0001
Hospital stay(day)	5.1±0.27	8.5±0.74	0.0001

Table 3 displays the frequency of post-operative complications in the CP and OP groups, as well as the pre- and post-operative PFTs outcomes. The CP group had a lower prevalence of post-operative complications than OP group. Specifically, there was a greater prevalence of pleural effusion and lung atelectasis among OP group than CP group.

The pre-operative FEV1 was not significantly different across CP and OP groups (p=0.84). However, there was a statistical difference of post-operative FEV1 across two groups, with a mean post-operative FEV1 of 3.9±0.37 among CP group vs. 3.75±04.39 among OP group (p=0.042). Similarly, CP group had a significantly higher pre-operative FVC than OP group (p=0.0001), and this difference persisted in the post-operative period (p=0.0001). Furthermore, a significant difference in pre-operative FEV1/FVC was observed across two groups, with a mean pre-operative FEV1/FVC of 88.8±2.1 among CP group vs. 83.3±4.4 among OP group (p=0.0001). However, there was no significant difference in post-operative FEV1/FVC across two groups (p=0.28), although the

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CP group did have a slightly higher mean post-operative FEV1/FVC of 88.9±1.84 than 92.4±3 among OP group (p=0.0001).

Table 3. Pre- and post-operative (discharge date) pulmonary function tests in studied groups

	closed	**open**	P
Pre-operative FEV1	4.1±0.33	4 ±0.37	0.84
Post-operative FEV1	3.9±0.37	3.75±04.39	0.042
P1	0.001	0.0001	
Pre-operative FVL	5.4±0.25	4.4±0.42	0.0001
Post operative FVL	5.3±0.24	4.3±044.	0.0001
P1	0.002	0.0001	
Pre operative FEV1/FVL	88.8±2.1	83.3±4.4	0.0001
Post-operative FEV1_FVL	88.9±1.84	92.4±3	0.0001
P1	0.28	0.0001	

The p-values in Table 3 represent the within-group comparisons of pre-operative and post-operative PFTs results. For the CP group, there was a significant decrease in post-operative FEV1 compared to pre-operative FEV1 (p=0.001). However, there was no significant difference in pre-operative and post-operative FVC (p=0.002) or FEV1/FVC (p=0.28) in the CP group. For the OP group, there was a significant decrease in post-operative FEV1 (p=0.0001) and FVC (p=0.0001) compared to pre-operative values. Additionally, OP group demonstrated a significant rise in post-operative FEV1/FVC in comparison to pre-operative levels (p=0.0001).

Table 4 presents PFTs outcomes that were performed before and after surgery, as well as post-operative complications incidence among CP and OP groups.

There was no significant difference between the two groups in terms of re-exploration or wound infection rates (p=0.99 for both). However, CP group exhibited a significantly lower occurrence of atelectasis relative to OP group, with only 8 (16.7%) patients among CP group experiencing atelectasis vs. 20 (41.7%) among OP group (p=0.007). Likewise, CP group demonstrated a significantly lower prevalence of pleural effusion relative to OP group, with only 2 (4.2%) patients among CP group experiencing pleural effusion vs. 13 (27.1%)

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among OP group (p=0.002).There were no reported cases of intra-aortic balloon pump (IABP) use or mortality in either group.

Table 4. Incidence of post-operative complications.

Variables	Studied groups		p-value
	Closed n.48	open n.48	
Re exploration	2(4.2)	3(6.3)	0.99
Wound infection	3(6.3)	4(8.3)	0.99
Atelectasis	8(16.7)	20(41.7)	0.007*
Pleural effusion	2(4.2)	13(27.1)	0.002*
IABP	0.0	0.0	
mortality	0.0	0.0	

DISCUSSION

The LIMA is a frequently utilized conduit for myocardial revascularization and is preferred over the saphenous vein due to its advantages. However, the optimal surgical technique for LIMA harvesting remains a topic of debate among surgeons [9]. In our study, LIMA harvesting was performed using two main techniques based on surgeon preference: preserving pleural integrity or opening the pleura. The decision to maintain or open the pleura during LIMA harvesting is an important consideration, as it can impact postoperative outcomes such as pulmonary function and risk of complications. Our study provides evidence supporting the benefits of preserving pleural integrity with the CP technique, which may offer advantages over the traditional open pleura approach.

Our prospective study was conducted to assess LIMA harvesting effectiveness among patients undergoing CABG surgery. The study involved a comparison between closed pleura LIMA harvesting and open pleurotomy and included 96 patients split into two groups. The first group of 48 patients had closed pleura LIMA harvesting, while the second had open pleurotomy.

Our results regarding patients' demographic characteristics across CP and OP groups were comparable, with no statistical differences observed in terms of age, sex, or prevalence of comorbidities. This suggests that the two groups were well-matched, which is important for ensuring that any observed differences in

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outcomes can be attributed to the surgical technique used (closed versus open pleura LIMA harvesting) rather than demographic or clinical differences between the patient groups. These results in line with prior investigations by Kumar et al. [10] and Ghavidel et al. [9], which also reported similar demographic characteristics between patient groups.

Our findings indicate that closed pleura LIMA harvesting offers significant advantages in terms of post-operative outcomes. CP group had significantly shorter ventilation time, ICU, and hospital stays than OP group. These results suggest that closing the pleura during LIMA harvesting leads to quicker recovery and reduced hospitalization periods. These benefits are crucial not only for improving patient comfort and quality of life but also for optimizing resource utilization and reducing the burden on healthcare facilities.

Furthermore, the CP group exhibited a lower prevalence of post-operative complications, particularly pleural effusion, and lung atelectasis, relative to OP group. This is in agreement with prior research that have highlighted the role of an intact pleura in preventing these complications [11-14]. By preserving the integrity of the pleura, closed pleura LIMA harvesting may help maintain normal respiratory function and minimize pulmonary complications risk [10].

Several studies have reported that post-operative complications, such as pleural effusion and atelectasis, are significantly greater among pleurotomy patients during surgery than those with an intact pleura. Rolla et al. [15] reported no rise in prevalence of atelectasis or pleural effusion in patients who underwent LIMA harvesting with an open pleura approach. In contrast, Lim et al. [16], Atay et al. [11], and Oz et al. [14] identified that patients who underwent intraoperative pleurotomy exhibited significantly higher rates of atelectasis and pleural effusion. Atelectasis may also be prevalent after CABG due to paralysis or paresis of the diaphragm, as demonstrated by Fedullo et al. [17], who utilized ultrasound to document left diaphragm dysfunction among 16% of patients post CABG. Additionally, studies have shown that pleural effusion incidence is 5-11% in patients with an intact pleura, but this rises to 20-50% in patients whose pleura was opened during LIMA harvesting [1, 18]. These findings support the benefits of preserving pleura integrity during LIMA harvesting, as observed in our study,

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which revealed a significant decrease in post-operative complications with an extrapleural approach.

The higher incidence of pleural effusion in the OP group can be attributed to the opening of the pleura itself, as well as the drainage of bleeding points from the mammary bed and mediastinum into the pleural cavity, which can result in minimal collection and irritation of the pleura, leading to pleural effusion. Additionally, pleural tube presence may cause irritation to the pleura and contribute to pleural effusion [6].

Our study also assessed pulmonary function using pre- and post-operative measurements. The results revealed that the CP group had superior post-operative PFTs than OP group, as evidenced by higher FVC and FEV1 values. These findings further support the notion that closed pleura LIMA harvesting contributes to better preservation of pulmonary function.

Our PFTs data demonstrated a statistically significant decline in post-operative results relative to pre-operative, irrespective of the technique utilized. However, when comparing PFTs between two groups, a statistically significant difference was found in favor of CP group for FEV1% and FVC%. Furthermore, a PFT results between the day of discharge and post-operative period revealed that CP group exhibited significantly higher FEV1% and FVC% values, while no significant difference was observed in FEV1/FVC ratio (P=0.28). These findings are in line with prior investigations in the literature, which have also documented changes in PFTs following cardiac surgery [19, 20].

As noted by Clark SC [21] study, the decline in post-operative PFTs may be caused by factors such as an open pleural space and manipulation of the lungs during surgery, which can alter surfactant levels and compromise alveolar integrity. These changes can contribute to a decline in PFTs at the time of discharge.

While some previous studies have suggested that preserving pleural integrity during cardiac surgery may have a limited impact on post-operative PFTs, our study provides evidence to the contrary. Matsumoto et al. [22] reported that pleurotomy had little impact on post-operative FEV1 at days 20 to 30 post-

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operative. However, our results propose that preserving pleural integrity with the CP technique can significantly positively impact post-operative PFTs. Similarly, Iskesen et al. [23] found that pleura preservation did not improve respiratory functions during cardiac surgery, but our results suggest otherwise.

Post-operative bleeding is a significant concern, and previous studies have reported varying outcomes regarding blood loss between the OP and CP techniques. Wimmer-Greinecker et al.[19] reported that participants in their OP group lost considerably more blood than those in their CP group (608658 mL vs. 470648 mL; p=0.027), which was supported by similar findings indicated by Atay et al. [11] and Iskesen et al. [23]. However, our analysis found no significant differences in blood loss across two groups (p-value= 0.9). This discrepancy in results may be attributed to the limited sample size of our study or the use of careful surgical methods to minimize blood loss.

It is important to note that our study did not find significant differences across two groups regarding re-exploration or wound infection rates. This suggests that closing pleura during LIMA harvesting does not increase the risk of these complications, thus supporting the safety of the closed pleura approach. However, there are statistically significant improvements in the closed group regarding ventilation duration, ICU, and hospital stays better than in OP group.

Prolonged ventilation time and ICU/hospital stays have been associated to surgical complications like atelectasis, pleural effusion, and pain from chest tube insertion [9]. While one study found no significant difference in ventilation time between two groups [18], other authors have reported that ventilation duration was significantly shorter among closed group than open group [1, 9].

Strengths and limitations:

Our study's strengths include the use of blinded patient selection, comprehensive laboratory investigations, and the exclusion of potential confounding variables that could affect the outcome. However, there are limitations to our study. One limitation is the relatively limited sample size, which may limit the generalizability of our findings. Additionally, PFTs were only performed on the day of discharge, which may not fully identify pulmonary function changes over time. Finally, we did not collect data on the cost-effectiveness of each approach,

Print ISSN 2636-3224
Online ISSN 2636-3232

which may be an important consideration for healthcare providers and institutions.

Conclusion

our study supports the use of closed pleura LIMA harvesting in patients undergoing CABG. This technique is associated with decreased post-operative morbidity, including a lower incidence of pleural effusion and atelectasis, as well as improved post-operative pulmonary function. The benefits of closed pleura harvesting include shorter ventilation time, ICU/hospital stays, as well as reduced post-operative pain. These findings have important implications for improving patient outcomes and optimizing resource utilization in CABG. Further research and larger studies are warranted to validate these results and explore long-term outcomes.

IRB#:10220/7-12-2022

Financial support and sponsorship

None.

Conflicts of interest

No conflicts of interest.

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Online ISSN 2636-3232